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Seeking research-enhanced geoscience outreach that complements subject knowledge with pedagogical expertise (Book Review)

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BOOK REVIEW

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Geoscience research and outreach: schools and public engagement (Innovations in Science Education and Technology, Vol. 21), edited by V.C.H. Tong, Dordrecht, Springer, 2014, 340 pp., £90.00 (hardback), ISBN 978-94-007-6942-7

This new volume in Springer's series on *Innovations in Science Education and Technology*, edited by Tong, provides a window into geoscience education outreach projects and programs developed and implemented by geoscientists for the public, schools, teachers and students, and community members. In his introduction, Tong advocates for geoscientists to employ a 'research-enhanced outreach model' versus a 'research-dissemination model', in which both scientific and educational research findings inform outreach to schools and the general public. Tong proposes a long-term goal of inclusiveness when building relationships among geoscientists, educational systems and programs, and the public in response to his own critique of historically restrictive, outreach activities, e.g. relying nearly exclusively upon public lectures.

The organization of this volume reflects the use of a strong curricular lens, which can act as a foothold for geoscientists to brainstorm programs to address education and outreach challenges. Through considering how scientific research findings can be communicated and understood by the intended audience, the authors have offered a broad range of interesting approaches to learn about important geoscience concepts for scientific literacy. Included in the volume are three essays that offer: (a) an overview of perspectives on the importance of geoscience outreach and the responsibility of scientists to engage in such activities (by Bowring); (b) an approach to communicating findings about climate science to non-scientists (by Rogers); and (c) how capitalizing upon individual and institutional strengths, articulating expectations and building meaningful collaborations can help successfully implement scientists' outreach and education initiatives (by Saltzman). The majority of the volume is composed of 15 examples of outreach projects. Commendably, the editor has assembled an international collection of outreach initiatives from the European Union (and country-specific projects from Croatia, Denmark, England, Germany, and Italy), Canada, Hong Kong, the USA, and an initiative by researchers at the United Nations University based in Japan. Conspicuously, there are no outreach projects by geoscientists from the southern hemisphere, although the four chapters that compose the online project examples conducted outreach globally.

The science content of these projects is sound, relevant and engaging and many outreach activities used an inquiry-driven approach, e.g. Yoshikawa, Sparrow, and Stanilovskaya's project PALM that successfully engaged teachers and students in rural communities in monitoring permafrost as part of a larger understanding of global climate change. From this perspective, the volume is rich, accurate and current. There are some classic approaches (i.e. modelling) to important constructs, such as geologic time (Jacobsen in Denmark) and other types of activities to replicate how geologists use the evidence for dating the Earth through radioactive decay methods (Bookhagen et al. in Boston, Massachusetts, USA). Some projects focused on elementary students (e.g. Croatian meteorology outreach by Spoler Canic and Rasol) and elementary teachers (e.g. the US-based *Teaching with Great Lakes Data* website by Rutherford), and others on the secondary level (e.g. geology problem-based learning tutorials with Hong Kong teachers and students by Chan and Ho; student-created marine geoscience videos in Germany by Dengg, Soria-Dengg, and Tiemann). Climate change, specifically global warming due to human activities, was a frequently addressed topic throughout the volume. Climate change is the new 'hot button', controversial scientific issue in the USA, joining the age of the Earth and evolutionary theory (the US-based National Center for Science Education).[1]

The book is organized by specific features common to science curriculum, field-based activities, online lessons and workshops, as well as program-level design and a final section entitled 'Promoting Research-enhanced Outreach'. While this provides one way to approach structural features of outreach for scientists to consider for their own projects, it does little to organize the examples by types of common educational issues or particular successes with different audiences. For instance, it might have been of more utility to organize the projects and perspective essays by factors underlying geoscience misconceptions, or common perceptions, beliefs (religious or otherwise) and policy that have derailed geoscience education efforts, or teacher professional development initiatives, or challenges of providing outreach to rural and urban communities. Admittedly, there are many ways that the chapters could have been organized as there is much overlap among project characteristics and audiences, but the reader is left to discover these aspects without much other guidance than the index. It would have been useful to have included a matrix at the beginning of the volume that outlined such key aspects (i.e. *Where? What? Who? How?*) of each project and its audience(s) to help consumers more easily find useful information across the contributions.

Connecting outreach to learning theory and educational research

Understanding and structuring effective science education is a complex affair, both in informal and in formal contexts. It is for this reason that Tong urges geoscientists to work closely with colleagues with expertise in education. Outreach designers and implementers may run the risk of erroneously reinforcing people's pre-existing attitudes toward science and scientists, or at the least not effecting real or measurable change, especially if they lack knowledge of how people learn and how educational research is conducted. Without grounding their results to learning theory and significant research findings, scientists who are not science education experts may find themselves in a position of reinventing what is already readily available. Equally as important, geoscientists who lack social science research skills may not understand how to evaluate projects in reliable and valid ways to demonstrate the potential effectiveness of their outreach activities. Problematically,

those engaged in outreach may believe that they have effected change because their target audience exhibited interest and enthusiasm, but without appropriate analyses and longitudinal studies one cannot make credible claims that a change in understanding has occurred. For instance, at the time of their involvement in projects, teachers are often enthusiastic about participating in professional development, but only long-term professional development has been shown to change instructional practices (Blank, De las Alas, & Smith, 2008). While there are many opportunities to engage teachers in professional development, it is challenging to enact well-designed research within the tight budgets of short-term grants or other informal science events to follow up and observe how teachers teach post-professional development. In many respects, outreach becomes a 'labor of love' by those scientists who have a service-oriented disposition. This is echoed by Saltzman, in her chapter, who offers a refreshing model of a scientist–educator collaboration at Stanford University that is providing teacher professional development in climate change science.

Among many of the contributions there is a certain naivety with regard to what is known about cognition, conceptual change, motivation, beliefs and issues of student diversity and equity. Ironically, outreach is portrayed nearly wholesale as a one-way street from the work of the expert to the non-scientist. There are few references to the research on teacher education and professional development despite existing models for teacher learning and programs (e.g. Bell & Cowie, 2001; Cochran-Smith & Zeichner, 2010; Darling-Hammond & Bransford, 2007). One exception is a cognizant chapter by King, who not only has worked at length to promote and study geoscience education in the UK, but is also engaged in research to better understand teacher professional development and effectiveness of science teachers who teach geoscience.

Among the authors there is a wide range of awareness of how education experts can contribute to geoscience outreach. In some chapters, there are no references to educational research and in others there are many with a clear understanding of the scholarship and policy documents (e.g. Barber; Sparrow, et al.). While the collection of essays and examples of geoscience education outreach clearly spans the globe as well as showcases some innovative and inquiry-based, curricular approaches to engaging teachers, students, and the public in the research that geoscientists do, I was left still concerned, not unlike Tong, that outreach continues to be conducted by those who are not educational experts and are often reinventing the wheel. References like Diamond, Luke, and Uttal's (2009) *Practical Evaluation Guide: Tools for Museums and Other Informal Educational Settings*, which is a step-by-step guide for those new to evaluation, and Loucks-Horsley, Stiles, Mundry, Love, and Hewson's (2009) *Designing Professional Development for Teachers of Science and Mathematics* are good entry points.

From a practical sense of how these projects were enacted perhaps there is little to criticize, and certainly there has been much improvement in how outreach has been enacted by scientists, but from the perspective of science education research there are still many inconsistencies. Better anchoring both outreach programs initially and studying them carefully with learning theories, analytical lenses (e.g. identity, indigenous knowledge, and gender equity), and previous research findings in science education will help close the proverbial loop. In the end, while I appreciated the authors' sharing of their ideas and projects and believe that many recipients' scientific lives were enriched as a result of these outreach programs, I was left wishing that more authors had referenced existing scholarship that would have enabled them to more strongly build upon the work of others; and, as Tong encouraged in his introduction, reached out more to discipline-based education researchers and science education colleagues to be more intimately involved with their

projects, ultimately viewing outreach as an interactive process where project parameters are co-generated.

Again, there are some exceptions and exemplars in the book; for example, Bookhagen et al. have methodically aligned their outreach and evaluation with many key studies about geologic time; Rutherford's chapter on guided inquiry tools carefully refers to the American geoscience education position documents by Barstow and Geary (2002) and national science education standards; and Chan and Ho's chapter on problem-based learning offers a solid review of other educational research in this space and the learning theories undergirding the project, but there are no references to recent science education research synthesis chapters from the *Handbook of Research on Science Education* (Abell & Lederman, 2007) or the first (Tobin & Fraser, 2003) or second (Fraser, Tobin, & McRobbie, 2012) editions of the *International Handbook of Science Education*. While some contributions reference formal education standards, no one mentions the informal science education standards (Bell, Lewenstein, Shouse, & Feder, 2009) offered in *Learning Science in Informal Environments: People, Places, and Pursuits*, that have been developed in the USA. There are some references to articles published in the *Journal of Geoscience Education*. However, there was no use of, or reference to, the significant work on geoscience misconceptions or the geoscience concept inventory (e.g. Libarkin & Anderson, 2005), the affective domain and motivation (e.g. van der Hoeven Kraft, Srogi, Husman, Semken, & Fuhrman, 2011), or underrepresented students (e.g. Riggs, Robbins, & Darner, 2007; Riggs & Semken, 2001) in the geosciences. While more research is needed in geoscience education, many scholars (e.g. Dodick & Orion, 2003; Mayer, 2002) have already described and grappled with key sociocultural issues surrounding geoscience education (as highlighted in Lewis & Baker, 2010).

We, the broader global community of scientists and science educators, often cite the necessity for scientific literacy for citizens in the hope that people will make better-informed choices for the environment, for sustainability and for healthier lives for people everywhere. Thus, outreach to various citizen groups is vitally important. This collection both provides carefully detailed examples of, and makes a strong case for, connecting children, teachers and the general public with geoscientists who are passionate about their work and can provide interesting, authentic, experiences within socio-scientific significant topics. But like the ratio of scientists to the public, there are fewer certified science teachers than scientists, and even fewer science education researchers than science teachers. In many ways some of the frustration that scientists feel towards the common scientific misconceptions held by the public about scientific concepts and practices, is reflected in how experts in science education feel similar frustration regarding misconceptions about learning, conceptual change and other educational issues held by scientists as well as in relation to their lack of understanding of how social science research is conducted. As a former geologist who became an Earth and space science teacher and then a science teacher educator and educational researcher, I can empathize with each perspective and set of concerns, and both are equally valid. In conclusion, I echo Tong's plea, that not only does there need to be a better, more inclusive model for outreach, but also a more integrative model for encouraging and structuring communication among scientists and educational experts so that our mutual goals can be attained for a better-educated public and improved stewardship of the Earth.

Notes

1. In the USA, the religious, right-wing has pushed conservatism to become more and more extreme, enacting a 'war on science' (Mooney, 2005), especially since the last Bush administration in which scientific findings in reports to Congress were changed to undercut the preponderance of evidence that global warming is being caused by human activity. However, this sort of political connection is not mentioned in this volume and while Rogers correctly and clearly identifies the problem of communicating scientific findings to a largely geoscience-illiterate public in his essay on communication between climate change scientists' findings and the public, he does not mention why this might be the case or refer to educational research on beliefs and conceptual change (e.g. Chinn & Brewer, 1993).

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